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## Empowering Future Project Managers: The Role of Experiential Learning, Soft Skills and Sustainable Practices in Engineering Project Management Education

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### ABSTRACT

#### BACKGROUND & CONTEXT

Project management education plays a critical role in preparing students for the dynamic and complex nature of real-world project environments. As organizations increasingly demand professionals who can navigate uncertainty, optimize risks, and demonstrate leadership, there is a growing need for experiential learning approaches that go beyond traditional lecture-based instruction. One such approach is Project-Based Learning (PBL), which engages students in hands-on, collaborative projects that mirror real-world challenges. PBL has been widely recognized for fostering essential project management competencies, including problem-solving, teamwork, critical thinking, and adaptability.

#### PURPOSE OR GOAL

Despite the benefits of PBL, challenges persist in its effective implementation. Research has shown that students often struggle with navigating project complexity, managing group dynamics, and transitioning to self-directed learning models. To address these issues, this study examines the effectiveness of PBL in enhancing students' understanding of PMBOK® Guide principles, with a particular focus on leadership behavior, risk management, and adaptability. By analyzing post-test assessments following project completion, this research seeks to identify key factors influencing student learning, the strengths of the PBL approach, and areas for further refinement.

#### APPROACH OR METHODOLOGY

Data was collected from 100 students enrolled in an undergraduate engineering course at a public university in Malaysia during semester two of 2024/2025 academic year through an online questionnaire.

#### OUTCOMES

Data from 100 students established benefits of experiential learning – improved – essential to project management. The analysis of post-project assessments indicates that students demonstrated a strong understanding of key project management principles, with mean scores across PMBOK® Guide principles ranging from 4.1 to 4.5. The results suggest that PBL effectively enhances students' ability to apply project management concepts. The high average ratings across PMBOK® principles ( $M > 4.0$  for all) indicate that students perceived their projects as well-aligned with fundamental project management principles.

## CONCLUSIONS

The findings indicate that integrating structured PBL frameworks with leadership training, complexity management workshops, and risk mitigation strategies could further enhance learning outcomes. Future iterations of the course may benefit from incorporating more case studies on complexity management, providing students with practical scenarios to enhance their ability to navigate intricate project dependencies. Additionally, implementing guided peer evaluation mechanisms could help ensure equitable participation in group work, addressing concerns about workload distribution and collaboration effectiveness. To further strengthen students' understanding of project dynamics, instructor-led simulations on adaptability and risk management could be introduced, reinforcing the interconnectedness of these principles and preparing students to handle uncertainties in real-world projects. Overall, these enhancements would build on the existing strengths of the project-based learning (PBL) approach, reinforcing its effectiveness in fostering key project management competencies while refining course delivery to better meet student needs.

## KEYWORDS

Project Management Education, Project Based Learning, PMBOK® Guide Principles.

## Introduction

The growing complexity of engineering projects and the dynamic nature of project environments have placed increasing emphasis on equipping future engineers with practical, transferable project management (PM) competencies (Kruger & Legoabe, 2020). Future engineering project managers are expected to not only have technical (discipline-specific) skills, but to also demonstrate a range of transferable skills including strong communication, problem-solving, collaborative leadership and strategic thinking skills will be increasingly valuable (PMI, 2023). These transferable skills are vital for engineers to succeed in complex, integrated projects and work alongside diverse stakeholders. Indeed, 2.3 million people will be needed each year to fill all the PM oriented positions in 2030 (PMI, 2024). Moreover, Generation Z engineering students (born from 1997 onward) (Dimock, 2019) need innovative educational approaches to develop soft skills, as traditional methods may not adequately engage them (Magano et al., 2021). These students have grown up surrounded by digital technologies, who value experiential and collaborative learning environments (Huss, 2023), needed to succeed in today's fast-changing job market. As reported by Department of Statistics, Malaysia in 2024, the country's Gen Z population exceeds 13.2 million, making up around 26% of the total population, with 4.4 million already entering the workforce between the ages of 22 and 26, positioning them as key contributors to economic growth. Despite this potential, cultivating soft skills in Gen Z engineers remains a pressing issue, as current educational and training frameworks still largely prioritize technical competencies (Buayai et al., 2025). Integrating active learning strategies and real-world problem-solving can significantly enhance their motivation and skill acquisition. Consequently, project management education must adopt more dynamic and learner-centered pedagogical approaches to effectively prepare future engineers to navigate uncertainty, manage risks, and lead diverse teams.

In response, universities have begun incorporating community-based engagement projects, especially with marginalized and resource poor communities (Málovics et al., 2024; (Hasan et al., 2023). The community engagements should enable the exchange of knowledge and enable learning for the benefit of society, either within or outside the university across local, national and international levels (Hasan et al., 2023). Community engagement in engineering education is grounded in constructivist theory, which posits that students learn most effectively through active participation in real contexts, especially when learning is reflective and socially embedded (Kolb, 1984). These real-life projects require students to collaborate across teams,

navigate project uncertainty and complexity, and communicate with non-technical stakeholders. As a result, students will need to exercise skills that requires them to quickly adapt to situations that are within and outside of their control (Tumpa et al., 2023) which are conditions that mirror the demands of professional engineering practice.

Previous research has highlighted the effectiveness of community engagement projects in fostering engineering students with hands-on experience, enhancing both technical and professional skills (Leidig et al., 2022; Goggins & Hajdukiewicz, 2022). These projects help students develop essential competencies such as communication, leadership, and interdisciplinary collaboration, which are crucial for their future careers (Kamel & Lim, 2012; Winkelman et al., 2016, Rivera et al., 2021). Furthermore, participation in community engagement projects can increase students' motivation to stay in engineering programs by making their learning experiences more relevant and impactful (Stepback, 2024).

Nevertheless, experiential learning theories (Kolb, 1984) provide a theoretical foundation for the use of community engagement in professional education, emphasizing the role of reflection, iteration, and social interaction in deepening conceptual understanding. However, despite the support for community engagement in undergraduate education, its implementation in project management education remains challenging. For example, implementing community engagement projects can be resource-intensive, requiring significant time, funding, and coordination between universities and community partners (Che Din et al., 2023). Moreover, students frequently struggle with navigating the complexity of open-ended tasks, managing group dynamics, and adapting to self-directed learning environments (Haenen et al., 2025). These challenges underscore the need for research evaluating how involvement in community engagement projects influences not only knowledge acquisition, but also the development of specific project management behaviours and attitudes.

The Project Management Body of Knowledge (PMBOK), developed by the Project Management Institute (PMI), is a globally recognized standard that outlines best practices, guidelines, and terminologies essential for effective project management. Currently in its seventh edition, project management is structured around five key process groups that represent the major phases of a project's lifecycle. These include Initiating, which involves defining the project need and gaining authorization to proceed; Planning, where objectives are set, scope is clarified, and detailed strategies are developed; Executing, which focuses on implementing the project plan and delivering outputs; Monitoring and Controlling, which entails tracking progress, managing changes, and ensuring alignment with goals; and Closing, which finalizes all project activities and confirms deliverables meet quality standards.

Complementing these process groups are ten knowledge areas that span the technical and managerial aspects of project execution. These include Integration Management, which ensures all components of the project work cohesively; Scope Management, which defines and controls what is and isn't included in the project; Schedule Management, which establishes and maintains project timelines; and Cost Management, which ensures budgetary control. Quality Management ensures deliverables meet predefined standards, while Resource Management focuses on optimizing the use of human and physical assets. Communications Management governs the flow of information among stakeholders, and Risk Management addresses potential threats and opportunities. Procurement Management involves sourcing necessary goods and services, and Stakeholder Management focuses on identifying, engaging, and satisfying those affected by the project. Together, these process groups and knowledge areas form a comprehensive framework for managing projects effectively.

Next, the guide also covers the twelve PMBOK project management principles which serves as foundational guidelines to inform effective and ethical project management practices. These principles begin with stewardship, emphasizing integrity, responsibility, and awareness of social, financial, and environmental impacts. The team principle highlights the importance of collaboration, recognizing that collective effort often surpasses individual capabilities. Stakeholder engagement is seen as crucial to achieving successful outcomes and fostering

satisfaction. The principle of value delivery focuses on aligning project outcomes with the intended benefits, whether realized during or after the project lifecycle. Systems thinking promotes a holistic understanding of internal and external influences on the project. Leadership is encouraged at all levels, with adaptability and empathy viewed as essential traits. Tailoring calls for customizing processes to suit the unique context of each project, ensuring optimal results while managing cost and effort. Quality emphasizes fulfilling stakeholder expectations through clearly defined acceptance criteria. The principle of complexity addresses the challenges that arise from systems interactions, uncertainty, and human behaviour. Risk management involves identifying and handling both threats and opportunities to enhance project success. Finally, adaptability and resilience support responsiveness to change, while the change principle advocates for structured transition strategies to minimize resistance and ensure sustainable adoption of outcomes.

However, little empirical research has examined how community engagement project interventions support students' internalization and application of these ten knowledge areas, particularly in areas critical to project success such as leadership behaviour, risk management, and adaptability. Understanding the link between these 12 PM principles is also underexplored, despite increasing recognition that successful project execution often depends on an individual's ability to integrate cognitive and behavioural competencies under uncertainty. Thus, this study investigates three primary questions:

- 1) To what extent do students perceive alignment between their community engagement project based learning experiences and the 10-core project management knowledge areas outlined in the PMBOK® Guide (7th Edition)?
- 2) What is the level of perceived team performance across the five project management process groups (Initiation, Planning, Execution, Monitoring, and Closing)?
- 3) To what extent do students perceive alignment between their community engagement project based learning experiences and the 12 core project management principles outlined in the PMBOK® Guide (7th Edition)?

These questions are important in engineering education because they address the effectiveness of instructional methods intended to develop both technical and soft skills, which are critical competencies for future engineers tasked with leading complex projects in a world which is volatile, uncertain, complex and ambiguous (VUCA). Moreover, by exploring these questions we can investigate whether undergraduates gain insights of how established standards, such as the PMBOK principles, process groups, and knowledge areas translate into practical and effective project execution. Specifically, how professional values (e.g., stewardship, leadership, adaptability), structured methodologies (e.g., planning, executing, monitoring), and cross-functional knowledge (e.g., risk, quality, stakeholder management) contribute to successful project outcomes. Furthermore, these questions encourage students to reflect on how these principles apply in their own project, thus, helping them to become adaptive, ethical, and value-driven project managers.

This study was conducted among 100 undergraduate engineering students enrolled in a project management course at a public university in Malaysia during the 2024/2025 academic year. These students engaged in semester-long, team-based community engagement projects at an Orang Asli village and a multiracial secondary school with majority students from the lower income families. Their self-assessments on project management knowledge, skills, and application of PMBOK principles were collected through a post-project questionnaire.

This article is structured as follows. Section 2 reviews the relevant theoretical frameworks and empirical literature on community engagement based learning and project management education. Section 3 describes the research design, data collection, and analysis methods. Section 4 presents the key findings. Section 5 discusses the implications for engineering education and curriculum development. Finally, Section 6 outlines the study's limitations and identifies directions for future research.

## Context

The growing complexity of engineering practice has led to a pedagogical shift in higher education toward more active, applied learning methods. Service learning has become a widely adopted form of experiential learning in engineering education (Narong & Hallinger, 2024). Community engaged learning, particularly through service-learning, is increasingly recognized as a valuable pedagogical approach in engineering education due to its proven impact on enriching student learning and fostering skill development (Goggins & Hajdukiewicz, 2022). According to Bringle & Hatcher (1995), service-learning involves students participating in structured service activities that address genuine community needs, with reflective practices helping them deepen their understanding of course material, broaden their disciplinary perspective, and cultivate a stronger sense of civic duty. This study similarly values reflective practice as a tool for evaluating learning outcomes in a project-based community engagement learning, defined by teams working on projects with specific goals, assigned tasks, expected outcomes, and set deadlines, this approach frames learning as a process centered around project execution (Bell, 2010; Blumenfeld et al., 1991).

Community engagement project-based learning rooted in constructivist learning theory, has emerged as a prominent strategy to develop both technical and transversal competencies essential to engineering graduates. Deliberately incorporating service learning into the curriculum encourages students to embrace service-oriented values, enriches their educational journey, and shapes a distinct professional identity in aspiring engineers (Huff et al., 2015; Zoltowski & Oakes, 2014). A significant body of research highlights service learning in engineering education in its significant role in preparing students for their careers by fostering not only technical and project management skills but also critical thinking and ethical awareness (Huff, Zoltowski, and Oakes, 2016; Wait, Huffman, and Anderson, 2013; Huff et al., 2013). Studies by Bielefeldt, 2013; Huff et al., 2012; Mostafavi et al., 2016 demonstrated that service learning cultivates professional identity, boosts confidence, and develops essential competencies such as leadership, communication, interdisciplinary collaboration, and a sustainability-oriented mindset. Moreover, service learning encourages social awareness, civic responsibility, and a commitment to the public good within engineering practice (Bielefeldt, Amadei, and Sandekian, 2008; Paterson, 2010; Schneider, Lucena, and Leydens, 2009).

Despite these findings, specific investigations into the impact of service learning project-based learning on project management education remain limited. While there is evidence that it cultivates technical and transversal competencies, fosters ethical awareness, and promotes leadership, communication, and a sustainability mindset (Huff, Zoltowski, & Oakes, 2016; Wait, Huffman, & Anderson, 2013; Bielefeldt, 2013; Mostafavi et al., 2016; Bielefeldt, Amadei, & Sandekian, 2008), fewer studies have systematically evaluated how it supports understanding of standardized project management frameworks such as the PMBOK® Guide (PMI, 2021). This guide defines key performance domains including leadership, risk management, and adaptability which are domains that are often difficult to teach through traditional theoretical instruction alone (PMI, 2021).

Moreover, Narong & Hallinger (2024) highlight the need for further research to better understand and prepare for the unpredictable complexities students may face in community-based projects. For example, Muller, Dangur, and Benyamin (2019) emphasized the attitudinal difficulties faced by students when working on projects for individuals with disabilities, noting the need for self-reflection on personal biases before engaging in technical problem-solving. Tsang (2023) identified concerns related to students delivering 'professional services' in community contexts, such as managing liability, adhering to schedules, and ensuring accountability. Meanwhile, Lee, Berg, and Buchanan (2018) pointed to challenges in international service learning, including language barriers, unclear roles, limited resources, and navigating cultural differences. Although these obstacles present difficulties, they also provide students with opportunities for growth through real-world, hands-on experiences.

Thus, this study addresses these gaps by focusing on how service learning project-based experiences support undergraduate students' understanding and application of standardized project management frameworks, particularly the PMBOK® Guide, while navigating real-world challenges and developing professional competencies. By anchoring these constructs within the PMBOK® Guide framework, the study contributes to both pedagogical research and applied project management education. Furthermore, it investigates not only individual domain development, but also the interrelationship between competencies, a perspective largely absent from existing literature. In doing so, the current research provides a data-driven foundation for refining PBL approaches in engineering curricula, particularly in relation to integrating standardized PM principles with experiential learning strategies.

This study is grounded in the constructivist learning theory, which emphasizes learning as an active, contextualized process of constructing knowledge through experience and reflection. PBL aligns closely with this paradigm by immersing students in collaborative problem-solving experiences that reflect the ambiguities of actual engineering practice. In parallel, the study operationalises learning outcomes using the PMBOK® guide (7th edition) as a benchmark. This globally recognised framework identifies key performance domains in project management, including stakeholder engagement, team performance, risk management, and adaptability, which are competencies that PBL seeks to cultivate. Both constructivism for pedagogy and PMBOK® for content, provides a structured lens for both instructional design and outcome measurement.

## Methodology

A quantitative, post-intervention survey design was employed to investigate the extent to which Project-Based Learning (PBL) supports the development of project management competencies aligned with the PMBOK® Guide. Specifically, the study focused on student perceptions of learning in the domains of leadership behaviour, risk response optimization and adaptability following the completion of a structured PBL project. Participants were 100 undergraduate engineering students enrolled in a project management course at a Malaysian public university during the second semester of the 2024/2025 academic year. All students completed a team-based project using the PBL model, in which they were required to apply PM principles to a real-world community project for underserved communities i.e. the Orang Asli community and the B40 students at an urban secondary school setting. Over 8 weeks, students prepared STEM kits covering science principles to be piloted with these students as part of a community project. The STEM kits were developed to cover various science principles such as electricity, pressure, buoyancy targeted for secondary school students aged between 13-17 years old. The STEM kits were also made mostly of recyclable materials.

Data was collected via an anonymous online questionnaire distributed at the end of the course. The instrument included 12 Likert-scale items aligned with PMBOK® Guide (7th Edition) domains such as Leadership behaviour, Risk response optimization, Adaptability and resiliency, Stakeholder engagement, Value delivery, System interaction recognition and Project tailoring. Students also rated their team's effectiveness across key project management process groups: initiation, planning, execution, monitoring, and closing. Performance in core PM knowledge areas (e.g., Scope, Time, Cost, Communication, Risk, and Resource Management) was also evaluated.

## Results

This section presents findings from the post-project assessment administered to 100 undergraduate engineering students who completed the KKKF3103 Project Management course using a project-based learning (PBL) approach. The analysis focuses on the perceived development of project management competencies and the alignment of student experiences with PMBOK® Guide principles.

Table 1 presents basic descriptive statistics of the respondents in the study.

**Table 1: Participant Demographics**

| <b>Sex</b>               | <b>n</b> | <b>%</b> |
|--------------------------|----------|----------|
| Male                     | 62       | 62       |
| Female                   | 38       | 38       |
| <b>Age Group (Years)</b> |          |          |
| 21                       | 4        | 4        |
| 22                       | 61       | 61       |
| 23                       | 25       | 25       |
| 24                       | 4        | 4        |
| 25                       | 6        | 6        |

Students' perceptions of the KKKF3103 Project Management course were generally positive, as reflected in their responses across multiple items (see Table 2).

**Table 2: Perceptions on the KKKF3103 Project Management Course**

| <b>Items</b>                                                                                    | <b>Strongly Agree<br/>n (%)</b> | <b>Agree<br/>n (%)</b> | <b>Neutral<br/>n (%)</b> | <b>Disagree<br/>n (%)</b> | <b>Strongly Disagree<br/>n (%)</b> | <b>Mean</b> | <b>SD</b> |
|-------------------------------------------------------------------------------------------------|---------------------------------|------------------------|--------------------------|---------------------------|------------------------------------|-------------|-----------|
| I liked the PM course experience this semester                                                  | 60                              | 33                     | 5                        | 2                         | 0                                  | 4.51        | .69       |
| I had fun managing the PM project this semester                                                 | 56                              | 31                     | 9                        | 1                         | 0                                  | 4.46        | .71       |
| Do you think you know the role of empathy in PM better after the PM project experience?         | 45                              | 43                     | 8                        | 1                         | 0                                  | 4.36        | .68       |
| Do you think you know the role of human skills in PM better after the PM project experience?    | 48                              | 45                     | 7                        | 0                         | 0                                  | 4.43        | .63       |
| Do you think you know the role of communication in PM better after the PM project experience?   | 61                              | 37                     | 2                        | 0                         | 0                                  | 4.62        | .53       |
| Do you think you know the role of team building in PM better after the PM project experience?   | 58                              | 40                     | 1                        | 1                         | 0                                  | 4.59        | .57       |
| Do you think you know the role of problem solving in PM better after the PM project experience? | 56                              | 41                     | 3                        | 0                         | 0                                  | 4.57        | .56       |
| Do you think that it was useful to experience handling a PM project for your future career?     | 66                              | 32                     | 1                        | 1                         | 0                                  | 4.68        | .55       |

The findings indicate a large majority of students either agreed or strongly agreed that they enjoyed the course experience, with 60% strongly agreeing and 33% agreeing, resulting in a high mean score of  $M = 4.51$ ,  $SD = 0.69$ . Similarly, 87% of students agreed or strongly agreed

that they had fun managing their project, with a mean of 4.46 (SD = 0.71). In terms of learning outcomes, students reported increased awareness of key human-centered competencies in project management. Specifically, 88% of students agreed or strongly agreed that they better understood the role of empathy in project management (M = 4.36, SD = 0.68), and 93% reported better understanding the role of human skills (M = 4.43, SD = 0.63). Notably, nearly all students (98%) agreed or strongly agreed that they now understand the importance of communication in project management (M = 4.62, SD = 0.53), while similarly high ratings were observed for understanding the role of team building (M = 4.59, SD = 0.57) and problem-solving (M = 4.57, SD = 0.56). Finally, 98% of students found the experience of managing a project useful for their future careers, with 66% strongly agreeing and a mean score of M = 4.68 (SD = 0.55), the highest among all items. These findings indicate that the project management course not only fostered engagement and enjoyment but also contributed meaningfully to the development of soft skills and professional readiness.

Overall, the results suggest that the course was effective in fostering both affective and cognitive outcomes aligned with the intended learning objectives. The findings from this study demonstrate that the KKKF3103 Project Management course had a positive impact on students' learning experiences and professional development, particularly through its hands-on, project-based approach. High mean scores across all items indicate strong student satisfaction and engagement, aligning with prior research on the value of experiential learning in project management education (Huff, Zoltowski, & Oakes, 2016; Mostafavi et al., 2016).

Next, students reported a significant improvement in their understanding of key human-centered competencies outlined in the PMBOK® Guide, including communication, teamwork, empathy, and problem-solving. These are critical soft skills that support several of the PMBOK® principles, such as creating a collaborative project team environment, demonstrating leadership behavior, and effectively engaging with stakeholders. The high ratings for communication (M = 4.62), team building (M = 4.59), and problem-solving (M = 4.57) highlight the effectiveness of project-based learning in cultivating these essential skills, which are often underemphasized in traditional lecture-based instruction. Moreover, the strong endorsement of the project's relevance to future careers (M = 4.68) underscores the real-world value of integrating practical project experiences into undergraduate curricula. This aligns with the PMBOK® principle of focus on value and supports calls from the engineering education literature to prepare students not only with technical knowledge but also with transferable, career-ready competencies (Bielefeldt, 2013; Rivera, Smith, & Lucena, 2022). However, while the majority of students felt more confident in understanding human skills, empathy, and communication, slightly lower scores in empathy (M = 4.36) suggest that further instructional scaffolding may be needed to help students connect emotional intelligence to technical project outcomes. Embedding structured reflection and stakeholder engagement exercises may further enhance their appreciation of these dimensions.

Next, students were asked to identify the project management knowledge areas they found most challenging during their recent project experience. The most frequently cited areas were Schedule Management (n = 59, 59%), Communications Management (n = 54, 54%), and Risk Management (n = 54, 54%). Fewer students identified Procurement Management (n = 28, 28%), Resource Management (n = 31, 31%) and Scope Management Resource Management (n = 31, 31%) as significant challenges. See Table 3.

**Table 3: Project management knowledge areas did students find most challenging**

| Item                   | n  | %  |
|------------------------|----|----|
| Integration Management | 40 | 40 |
| Scope Management       | 31 | 31 |
| Schedule Management    | 59 | 59 |
| Cost Management        | 36 | 36 |

|                           |    |    |
|---------------------------|----|----|
| Quality Management        | 52 | 52 |
| Resource Management       | 31 | 31 |
| Communications Management | 54 | 54 |
| Risk Management           | 54 | 54 |
| Procurement Management    | 28 | 28 |
| Stakeholder Management    | 40 | 40 |

These findings suggest that students may benefit from enhanced instructional focus on the corresponding PMBOK® Guide knowledge areas such as Schedule Management, Communications Management, and Risk Management, as these domains are critical to effective project delivery. Strengthening competencies in these areas will better equip students to develop realistic timelines, facilitate clear stakeholder communication, and proactively manage uncertainties, all of which are essential for aligning with industry-standard project management practices.

**Table 4: Mean scores and standard deviations for team effectiveness in managing project management processes**

| Project Management Process |             | 1= Very Ineffective | 2= Ineffective | Neutral | Effective | 5= Very Effective | Mean (M) | Standard Deviation (SD) |
|----------------------------|-------------|---------------------|----------------|---------|-----------|-------------------|----------|-------------------------|
| Initiating                 | the project | 0                   | 0              | 7       | 34        | 59                | 4.52     | 0.63                    |
| Planning                   | the project | 0                   | 0              | 7       | 34        | 59                | 4.46     | 0.69                    |
| Executing                  | the project | 0                   | 2              | 5       | 38        | 55                | 4.47     | 0.75                    |
| Monitoring and controlling | the project | 1                   | 3              | 5       | 32        | 59                | 4.45     | 0.81                    |
| Closing                    | the project | 1                   | 0              | 4       | 35        | 60                | 4.53     | 0.67                    |

Students were asked to evaluate their team's effectiveness in managing core project management processes such as planning, executing, monitoring and controlling, and closing, on a 5-point Likert scale (1 = Not effective, 5 = Very effective). Overall, responses reflected a high level of perceived effectiveness across all process areas. The highest mean score was reported for closing the project (M = 4.53, SD = 0.67), followed closely by initiating (M = 4.52, SD = 0.63), indicating students felt most confident in starting and completing their projects. Executing and planning also received strong ratings (M = 4.47 and M = 4.46, respectively), while monitoring and controlling had the lowest, though still high, mean score (M = 4.45, SD = 0.81), suggesting slightly more variation in students' experiences in that phase.

The results suggest that students perceived their teams to be largely effective in carrying out all five core project management processes. The high ratings for initiating and closing may reflect the structured support typically available at the start and end of student-led projects, including clearly defined objectives and deliverables. Strong scores in planning and executing indicate that students were generally successful in translating plans into action, an essential competency emphasized in the PMBOK® Guide. Notably, monitoring and controlling received the lowest effectiveness rating and the highest variability, suggesting this area may pose greater challenges for student teams. This aligns with previous research indicating that performance tracking, issue resolution, and adapting to changes are complex skills that often require more experience and deeper understanding of feedback mechanisms and project

metrics (Huff, Zoltowski, & Oakes, 2016). It may also point to a need for enhanced instructional emphasis on real-time progress evaluation and iterative decision-making processes within student projects. These findings support the value of experiential project-based learning in developing practical competencies in line with PMBOK® processes, while also identifying monitoring and controlling as an area where students may benefit from additional scaffolding or guided tools in future course iterations.

**Table 5: Students' perceived alignment of their projects with PMBOK® Guide principles**  
(n= 100)

| <b>PMBOK® Principle</b>                                 | <b>1=<br/>Very<br/>Poor</b> | <b>2=<br/>Poor</b> | <b>3=<br/>Neutral</b> | <b>4=<br/>Well</b> | <b>5=<br/>Very<br/>Well</b> | <b>Mean<br/>(M)</b> | <b>Standard<br/>Deviation<br/>(SD)</b> |
|---------------------------------------------------------|-----------------------------|--------------------|-----------------------|--------------------|-----------------------------|---------------------|----------------------------------------|
| Be a diligent, respectful, and caring steward           | 0                           | 0                  | 5                     | 38                 | 57                          | 4.52                | 0.59                                   |
| Create a collaborative project team environment         | 0                           | 0                  | 7                     | 38                 | 55                          | 4.48                | 0.63                                   |
| Effectively engage with stakeholders                    | 0                           | 1                  | 11                    | 43                 | 45                          | 4.32                | 0.71                                   |
| Focus on value                                          | 0                           | 0                  | 6                     | 38                 | 56                          | 4.50                | 0.61                                   |
| Recognize, evaluate, and respond to system interactions | 0                           | 0                  | 9                     | 39                 | 52                          | 4.43                | 0.66                                   |
| Demonstrate leadership behaviour                        | 0                           | 0                  | 8                     | 43                 | 49                          | 4.41                | 0.64                                   |
| Tailor based on context                                 | 0                           | 0                  | 10                    | 41                 | 49                          | 4.39                | 0.67                                   |
| Build quality into processes and deliverables           | 0                           | 0                  | 10                    | 43                 | 47                          | 4.37                | 0.66                                   |
| Navigate complexity                                     | 0                           | 1                  | 10                    | 49                 | 40                          | 4.28                | .68                                    |
| Optimize risk responses                                 | 0                           | 2                  | 15                    | 39                 | 44                          | 4.25                | 0.78                                   |
| Embrace adaptability and resiliency                     | 0                           | 1                  | 8                     | 49                 | 42                          | 4.32                | 0.67                                   |
| Enable change to achieve the envisioned future state    | 0                           | 0                  | 10                    | 46                 | 44                          | 4.34                | 0.66                                   |

Students were asked to assess how well their project experiences aligned with the twelve principles of the PMBOK® Guide, using a 5-point scale ranging from Very Poor (1) to Very Well (5). Overall, responses indicated a high level of perceived alignment with all twelve principles. The highest mean score was reported for “Be a diligent, respectful, and caring steward” (M = 4.52, SD = 0.59), followed closely by “Focus on value” (M = 4.50, SD = 0.61), suggesting students strongly identified ethical responsibility and value delivery as embedded in their project experiences. Principles such as “Create a collaborative project team environment” (M = 4.48), “Recognize, evaluate, and respond to system interactions” (M = 4.43), and “Demonstrate leadership behaviour” (M = 4.41) were also rated highly. Lower, but still positive ratings were recorded for “Optimize risk responses” (M = 4.25, SD = 0.78), “Navigate complexity” (M = 4.28, SD = 0.68), and “Effectively engage with stakeholders” (M = 4.32, SD = 0.71), indicating these areas may have been more challenging or less emphasized in students' projects.

The results suggest that the student-led project experiences were well-aligned with the core values and principles outlined in the PMBOK® Guide. High ratings for stewardship, value

focus, and collaborative team environment indicate that students not only managed technical aspects of the project but also embraced ethical and interpersonal dimensions of project management. These findings reflect positively on the course design, which appears to have facilitated learning beyond process compliance, encouraging students to internalize principles of responsibility, team contribution, and value creation, which are elements critical for professional success in real-world project environments. The relatively lower ratings for risk optimization, stakeholder engagement, and navigating complexity suggest that students may require more structured opportunities to practice these advanced project management skills. These areas often involve uncertainty, negotiation, and adaptive strategies, which can be difficult for novice project managers to manage effectively without guided support. This aligns with prior research indicating that while technical tasks may be easier to teach, navigating dynamic project conditions and external stakeholder demands requires deeper experiential learning and reflection (Tsang, 2023; Huff et al., 2016). In future iterations of the course, targeted interventions such as scenario-based risk simulations, stakeholder role-play exercises, and complexity mapping activities could be integrated to strengthen student competencies in these areas. Overall, the strong alignment with PMBOK® principles reinforces the value of project-based learning as a powerful instructional strategy in project management education.

## Implications and Recommendations

The findings of this study underscore the potential of structured PBL frameworks, aligned with the PMBOK® Guide, to strengthen project management competencies among engineering students. Specifically, the integration of experiential learning with formal principles appears to support students' development of leadership skills, risk management strategies, and adaptive thinking. These are crucial capabilities in engineering contexts characterized by uncertainty and complexity. To enhance the effectiveness of such instructional approaches, future iterations of the course should consider embedding case studies that focus explicitly on complexity management. These would expose students to ambiguous, interdependent scenarios that mirror real-world project challenges. Additionally, the implementation of guided peer evaluation mechanisms may improve accountability and promote more equitable participation within teams, an area commonly identified as a weakness in collaborative learning. Instructor-led simulations that emphasize the interplay between risk response and adaptability could further reinforce students' understanding of how these principles co-evolve during a project lifecycle. Together, these refinements would help address current implementation challenges and optimize the pedagogical value of PBL in engineering education. While the current study demonstrates promising results, it also highlights areas for further investigation. Future research could explore the long-term impact of PBL-based project management education by tracking graduates into professional settings to determine whether perceived learning translates into actual workplace performance. Mixed-methods studies may offer deeper insights into students' cognitive and emotional responses to project complexity, helping educators refine scaffolding techniques for challenging learning environments. Furthermore, expanding the research across institutions, disciplines, and cultural contexts would help assess the generalizability of the findings and identify context-specific adaptations. These extensions would contribute to a more nuanced understanding of how PBL can be optimized to develop the competencies most relevant to engineering practice.

## References

- Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. *The Clearing House a Journal of Educational Strategies Issues and Ideas*, 83(2), 39–43. <https://doi.org/10.1080/00098650903505415>
- Bielefeldt, A. R. (2013). Pedagogies to achieve sustainability learning outcomes in civil and environmental engineering students. *Sustainability*, 5(10), 4479–4501. <https://doi.org/10.3390/su5104479>

- Bielefeldt, A. R., Amadei, B., & Sandekian, R. (2008). Community service learning in engineering education: What, why, and how? In American Society for Engineering Education Annual Conference & Exposition.
- Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating Project-Based Learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3–4), 369–398. <https://doi.org/10.1080/00461520.1991.9653139>
- Bringle, R. G., & Hatcher, J. A. (1995). A Service-Learning Curriculum for faculty. *Michigan Journal of Community Service Learning*, 2(1). <https://scholarworks.iupui.edu/bitstream/1805/4591/1/bringle-1995-service-learning.pdf>
- Che Din, M. A., Mohamed Zin, M., Norkhairi Ahmad, N., Adifarizal Mohd Ariffin, A., & Noor Kamsiah Che Ahmad, N. K. (2023). Undergraduates' perception of community service course narratives on challenges and initiatives at technical engineering university. *Journal of Digital Education, Communication and Arts*, 6(2), 77–87. <https://doi.org/10.30871/deca.v6i02.6884>
- Dimock, M. Defining Generations: Where Millennials End and Generation Z Begins. Pew Research Center. 2019 <https://www.pewresearch.org/short-reads/2019/01/17/where-millennials-end-and-generation-z-begins/>
- Goggins, J., & Hajdukiewicz, M. (2022). The role of Community-Engaged Learning in Engineering Education for Sustainable Development. *Sustainability*, 14(13), 8208. <https://doi.org/10.3390/su14138208>
- Hasan, S. I., Bakar, A. A., Radi, N. a. M., Mansor, M. A., Hamzah, Z. L., & Siddiq, A. (2023b). The Positive Impact of University-Community Engagement Projects: A case study in the context of Universiti Malaya. *Journal of Research Management & Governance*, 5(1), 30–49. <https://doi.org/10.22452/jrmg.vol5no1.3>
- Huff, J. L., Oakes, W. C., & Zoltowski, C. B. (2012). Developing a professional identity: A qualitative study of engineering students' community service experiences. *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*.
- Huff, J. L., Zoltowski, C. B., & Oakes, W. C. (2015). Preparing Engineers for the Workplace through Service Learning: Perceptions of EPICS Alumni. *Journal of Engineering Education*, 105(1), 43–69. <https://doi.org/10.1002/jee.20107>
- Huff, J. L., Zoltowski, C. B., Oakes, W. C., & Adams, R. S. (2013). Making sense of design: A collaborative study of engineering faculty perspectives on design thinking and teaching. *ASCE Annual Conference & Exposition*.
- Huss, J. (2023). Gen Z students are filling our online classrooms: do our teaching methods need a reboot? *InSight a Journal of Scholarly Teaching*, 18, 101–112. <https://doi.org/10.46504/18202306hu>
- Goggins, J., & Hajdukiewicz, M. (2022). The role of Community-Engaged Learning in Engineering Education for Sustainable Development. *Sustainability*, 14(13), 8208. <https://doi.org/10.3390/su14138208>
- Haenen, J., Vink, S., Sjoer, E., & Admiraal, W. (2025). Motivating students with optimal challenge in an open learning environment. *Social Sciences & Humanities Open*, 11, 101577. <https://doi.org/10.1016/j.ssaho.2025.101577>
- Kamel, F., & Lim, K. H. (2012, December). Art of engaging with the community for successful engineering projects. In *Proceedings of the 2012 4th International Congress on Engineering Education (ICEED 2012)* (pp. 1–6). IEEE. <https://doi.org/10.1109/ICEED.2012.6779261>
- Lee, T., D. R. Berg, and E. A. Buchanan. 2018. "Challenges and Opportunities in International Service Learning." In *ASCE Annual Conference and Exposition*, Salt Lake City, Utah, June 24–27, 2018.
- Kruger, D., & Legoabe, K. (2020). Developing engineers as project managers: an ongoing challenge. *International Journal of Constructive Research in Civil Engineering*, 6(3). <https://doi.org/10.20431/2454-8693.0603001>
- Magano, J., Silva, C. S., Figueiredo, C., Vitoria, A., & Nogueira, T. (2021). Project Management in Engineering Education: Providing Generation Z with transferable skills. *IEEE Revista Iberoamericana De Tecnologias Del Aprendizaje*, 16(1), 45–57. <https://doi.org/10.1109/rita.2021.3052496>
- Málovics, G., Bajmócy, Z., Csernák, J., Fehér, B., Frigyi, M., Juhász, J., Matolay, R., Müllner, A., & Szerencsés, R. (2024). The potential role of university community engagement in supporting transformative social innovation – experiences from Hungary. *Innovation the European Journal of Social Science Research*, 1–31. <https://doi.org/10.1080/13511610.2024.2399605>
- Mostafavi, A., Abraham, D. M., DeLaurentis, D., Sinfield, J. V., & Usher, J. M. (2016). Innovation in engineering education through student-centered design and learning. *Journal of Engineering Education Transformations*, 29(3), 81–87.

- Muller, O., V. Dangur, and O. B. Benyamin. 2019. "Developing Devices for People with Disabilities: Challenges and Gains of Project-Based Service Learning." *International Journal of Engineering Education* 35 (5): 1402–1414.
- Narong, D. K., & Hallinger, P. (2024). The evolution of service learning in engineering education: a bibliometric review of research (1995–2023). *European Journal of Engineering Education*, 49(5), 834–855. <https://doi.org/10.1080/03043797.2024.2368148>
- Paterson, K. (2010). Integrating engineering for global development with the engineering curriculum: A case study at the University of Colorado Boulder. *Journal of Engineering Education*, 99(3), 329–336.
- Project Management Institute. (2021). A guide to the project management body of knowledge (PMBOK® guide) (7th ed.). Project Management Institute.
- Rivera, J., Smith, J. M., & Lucena, J. C. (2022). Engineering to help: The professional formation of engineers through humanitarian and community engagement. *Engineering Studies*, 14(1), 45–67.
- Rivera, A., Smith, J., Lucena, J., Bullock, R., Phelan, T., & Smits, K. (2021). Making the most of virtual community engagement for international projects during the COVID-19 pandemic. 2020 ASEE Virtual Annual Conference Content Access Proceedings. <https://doi.org/10.18260/1-2--37477>
- Stepback, L., Leidig, P. A., & Oakes, W. C. (2024, June). Board 360: Reflections from Graduates on the Impact of Engineers Without Borders USA Experiences on Professional Preparation. 2024 ASEE Annual Conference, Baltimore, MD.
- Schneider, J., Lucena, J., & Leydens, J. A. (2009). Engineering to help: The value of humanitarian engineering. *IEEE Technology and Society Magazine*, 28(4), 28–35. <https://doi.org/10.1109/MTS.2009.934475>
- Tsang, E. 2023. *Projects That Matter: Concepts and Models for Service-Learning in Engineering*. New York: Taylor & Francis. <https://doi.org/10.4324/9781003446507>.
- Tumpa, R. J., Skaik, S., Ham, M., & Chaudhry, G. (2023). Enhancing project management graduates' employability through group assessment innovations: An empirical study. *Project Leadership and Society*, 4, 100084. <https://doi.org/10.1016/j.plas.2023.100084>
- Wait, D., Huffman, T., & Anderson, J. (2013). Service-learning in engineering education: A practical model for engagement at the regional level. *Journal of STEM Education*, 14(1), 54–61.
- Winkelman, P. M., Penner, J., & Beittoei, A. (2016). Sustainable Development for Engineers Through a Thematic Restructuring of Experiential Learning. In *World sustainability series* (pp. 309–321). [https://doi.org/10.1007/978-3-319-32933-8\\_26](https://doi.org/10.1007/978-3-319-32933-8_26)
- Wright, G., & Lewis, S. (2025, June 24). What is Project Management Body of Knowledge (PMBOK)? WhatIs. <https://www.techtarget.com/whatIs/definition/Project-Management-Body-of-Knowledge-PMBOK>
- Zoltowski, C. B., & Oakes, W. C. (2014). Learning by Doing: Reflections of the EPICS Program. *International Journal for Service Learning in Engineering Humanitarian Engineering and Social Entrepreneurship*, 1–32. <https://doi.org/10.24908/ijlsle.v0i0.5540>

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